Matthan: Drone Presence Detection by Identifying Physical Signatures in the Drone's RF Communication

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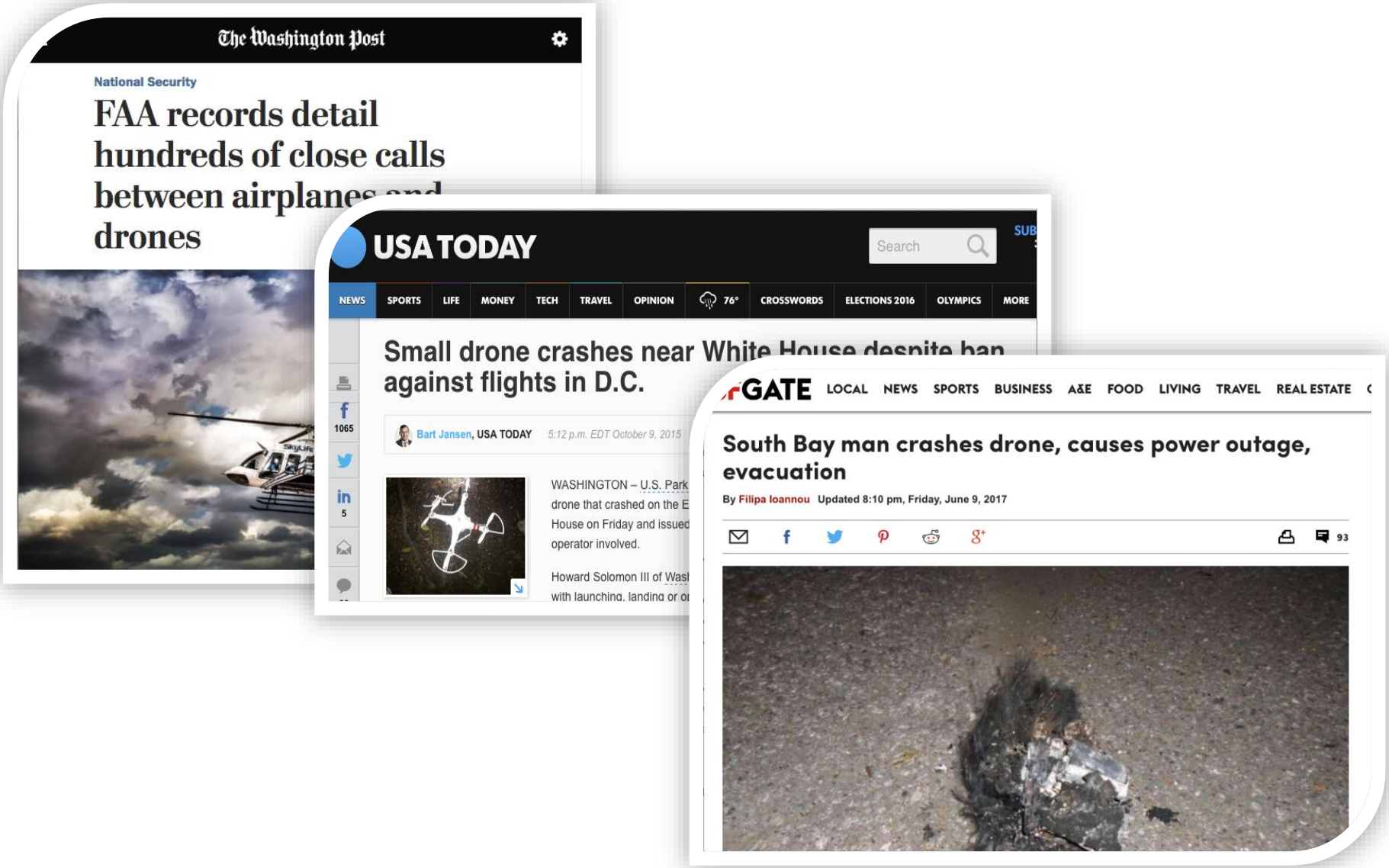
Drone accidents have increased



The Washington Post

National Security

FAA records detail hundreds of close calls between airplanes and drones

USA TODAY

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Small drone crashes near White House despite ban against flights in D.C.

Bart Jansen, USA TODAY 5:12 p.m. EDT October 9, 2015

WASHINGTON – U.S. Park
drone that crashed on the E
House on Friday and issued
operator involved.

Howard Solomon III of Wash
with launching, landing or o

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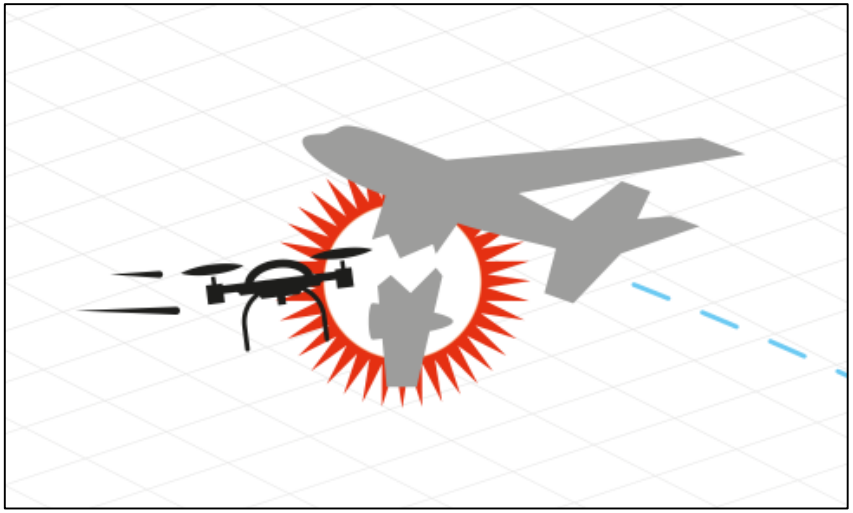
South Bay man crashes drone, causes power outage, evacuation

By Filipa Ioannou Updated 8:10 pm, Friday, June 9, 2017

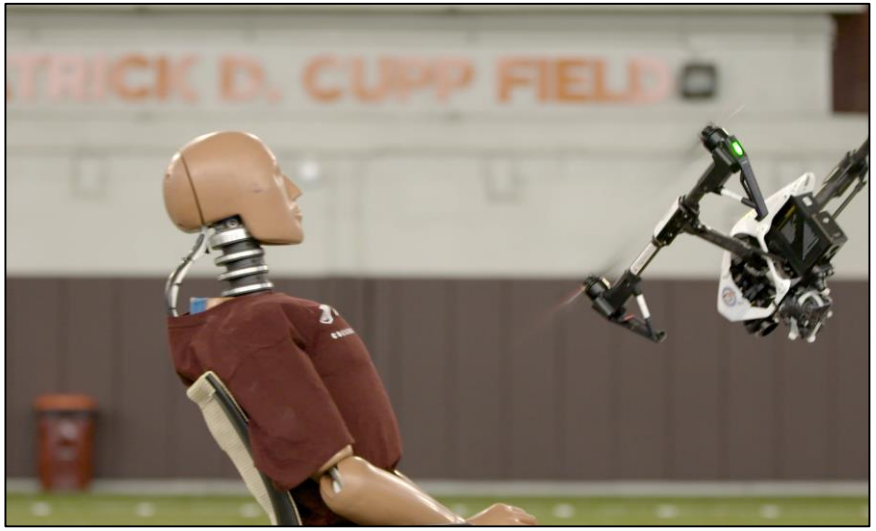
Drone accidents have increased

Drone Hits an Airplane

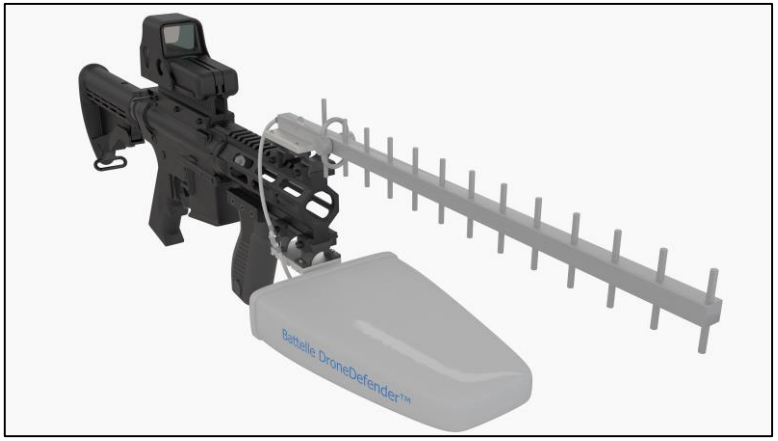


Drone Crashes Through Window

Drone Hits Man's Head



Ways to take down illegal drones



Battelle Drone Defender

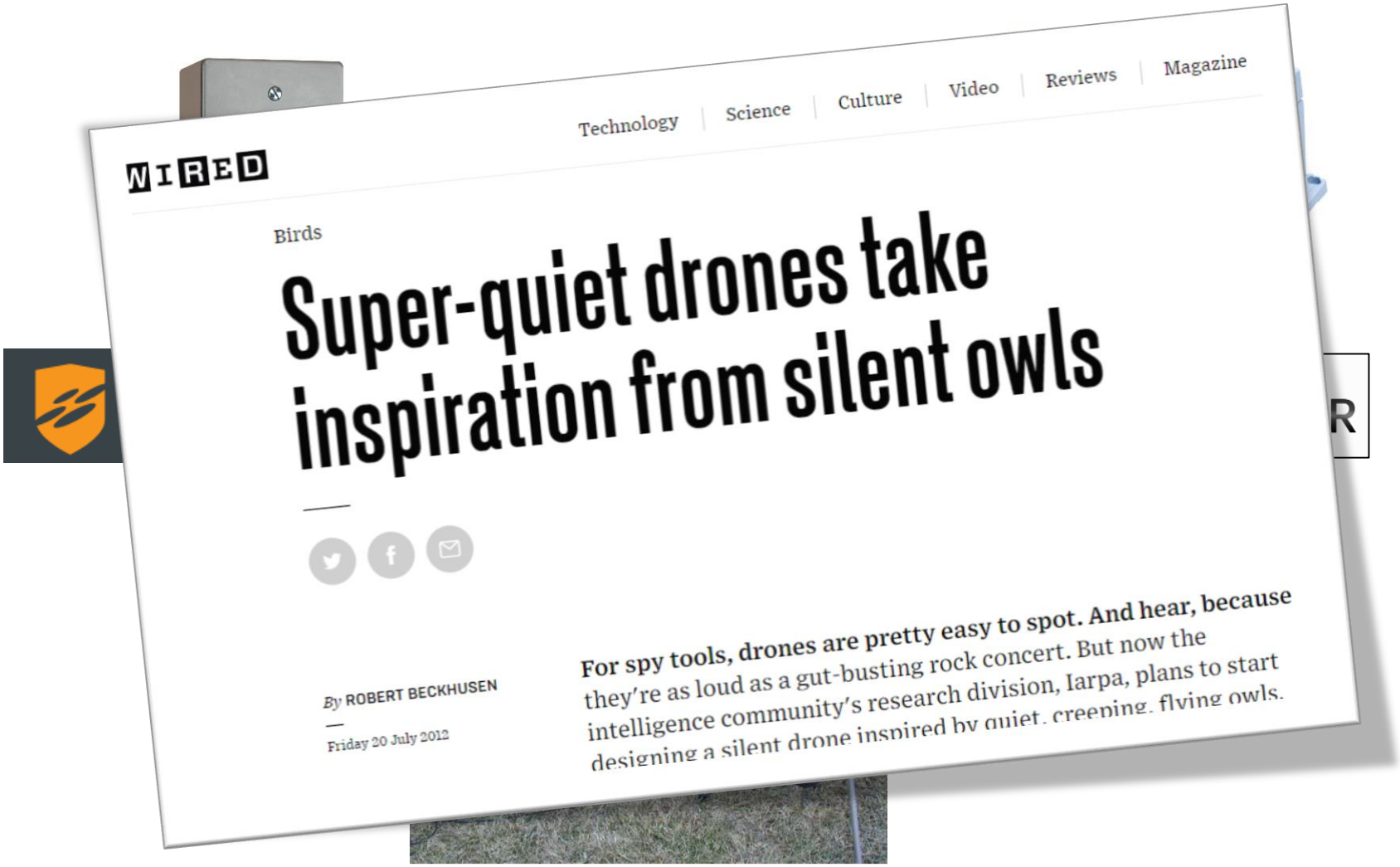
Skywall 100 Drone Defense System

Assume drone presence is known a priori

Excipio Anti Drone System

Drone Catching Eagles

Existing acoustic-based detection



WIRED

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Birds

Super-quiet drones take inspiration from silent owls

By ROBERT BECKHUSEN

Friday 20 July 2012

For spy tools, drones are pretty easy to spot. And hear, because they're as loud as a gut-busting rock concert. But now the intelligence community's research division, Iarpa, plans to start designing a silent drone inspired by quiet, creeping, flying owls.

Tien Pham et. al., U.S. Army Research Laboratory

Existing video-based detection

Tamas Zsedrovits et. al., 2011, 2012

Existing active radar-based detection

DeTect

This technique creates much interference to the environment and expensive

KELVIN HUGHES
SITUATIONAL INTELLIGENCE, THE WORLD OVER

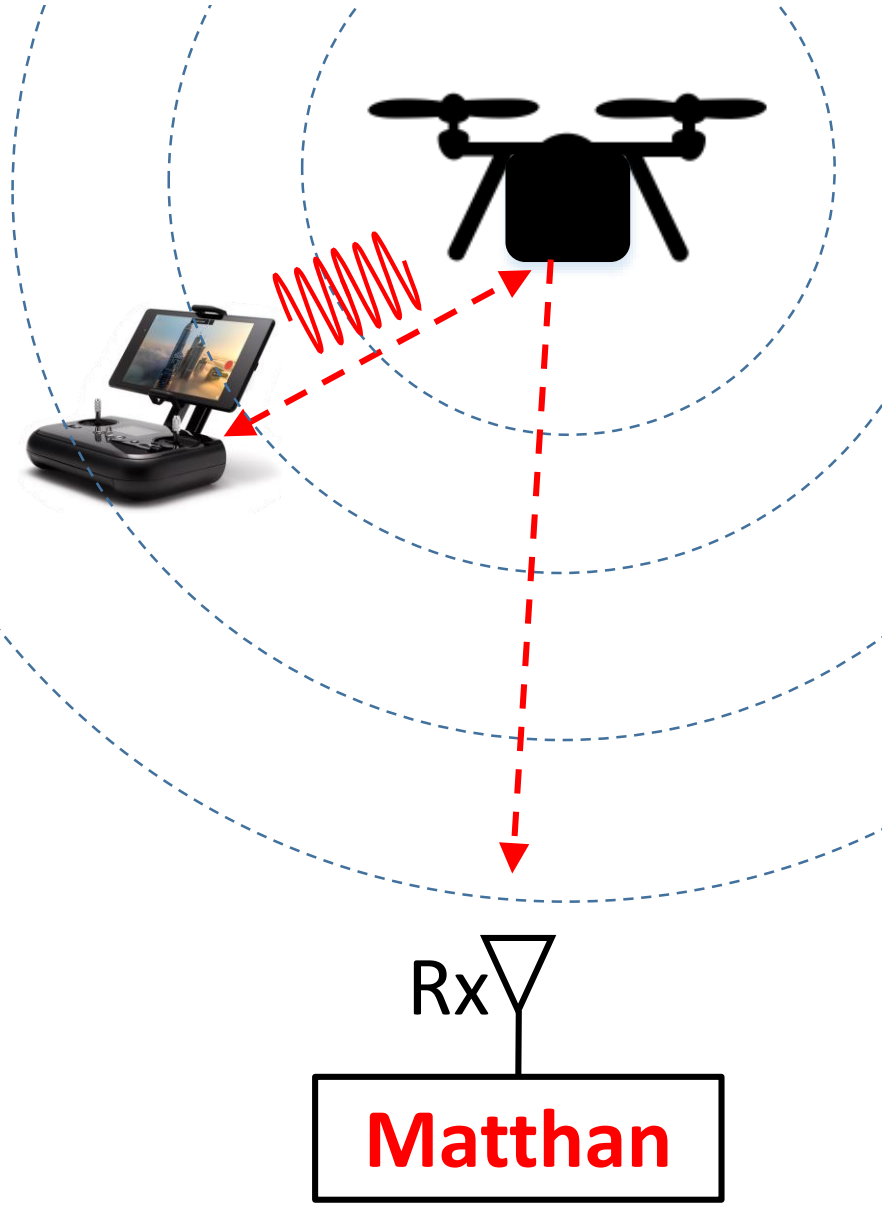
Can we detect the drone using a Wi-Fi access point?

- ✅ Cost-effective
- ✅ Ubiquitous
- ✅ Internet connected

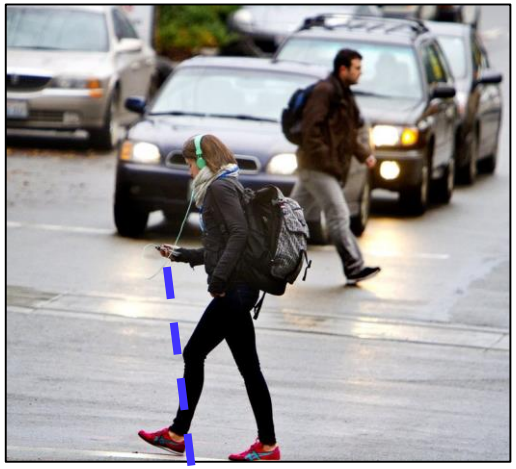
Matthan Drone Detection System

Explore physical signatures in the received RF signal:

- **Body Shifting** (caused by Control Loop Mechanism)
- **Body Vibration** (caused by Propellers Motion)



Challenges



Rx

Wi-Fi embedded Mobile devices

Rx

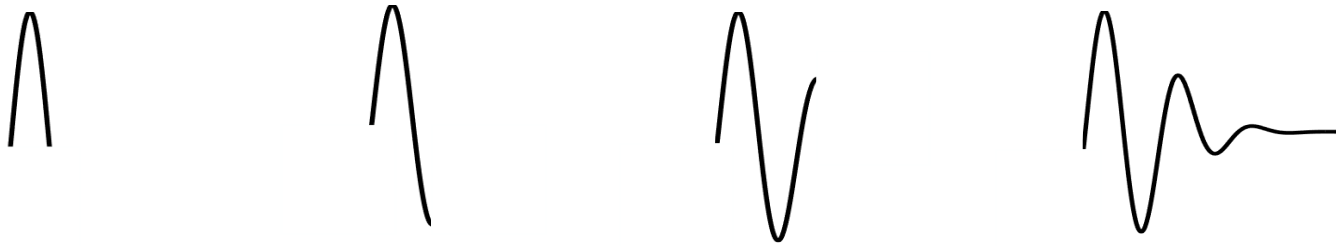
Wi-Fi hotspot inside moving vehicles

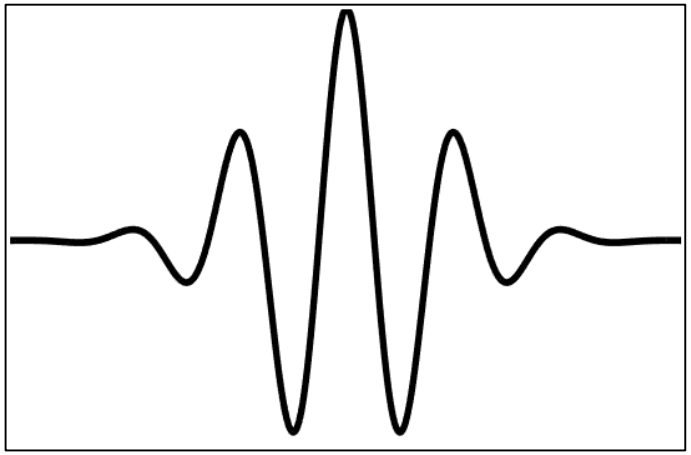
Rx

Drone movements can happen with unpredicted patterns

Body Shifting Observation

Corresponding movement waveform:





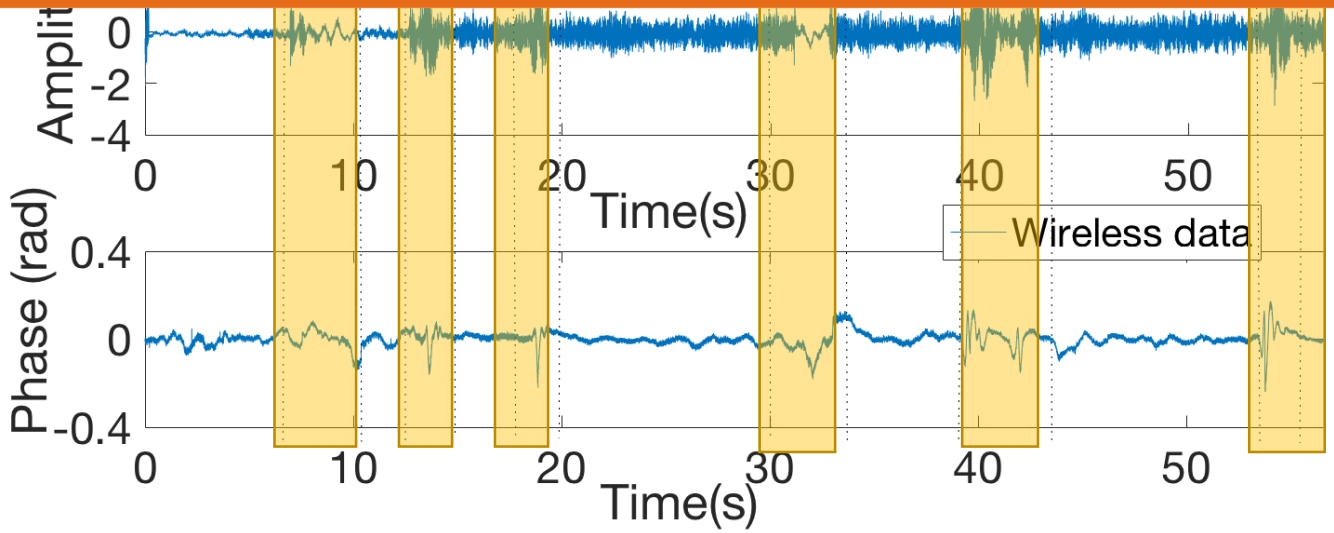
An example wavelet

<u>Idea:</u> The body movement of the drone can be detected by a wavelet transform analysis

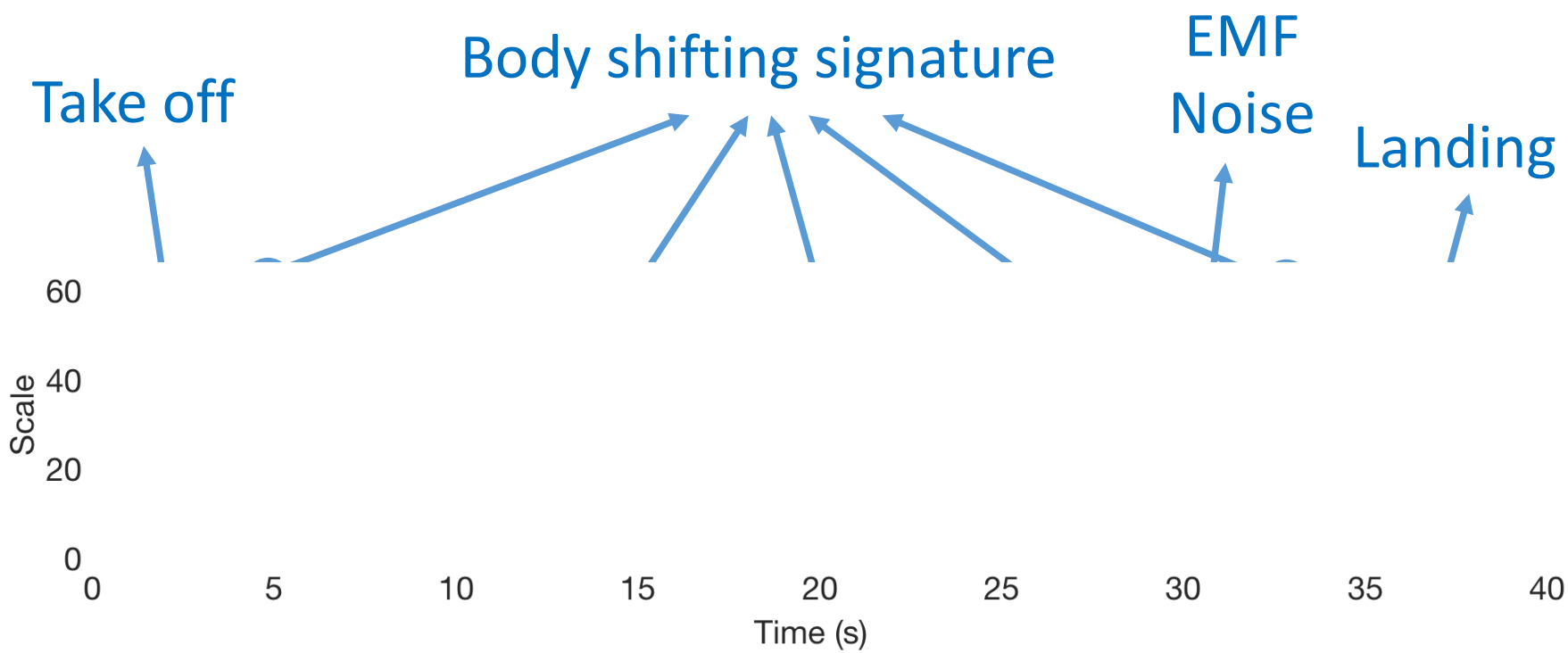
Body Shifting Validation

- Drone is attached TX antenna and IMU
- Observe the signal from IMU and RX when the

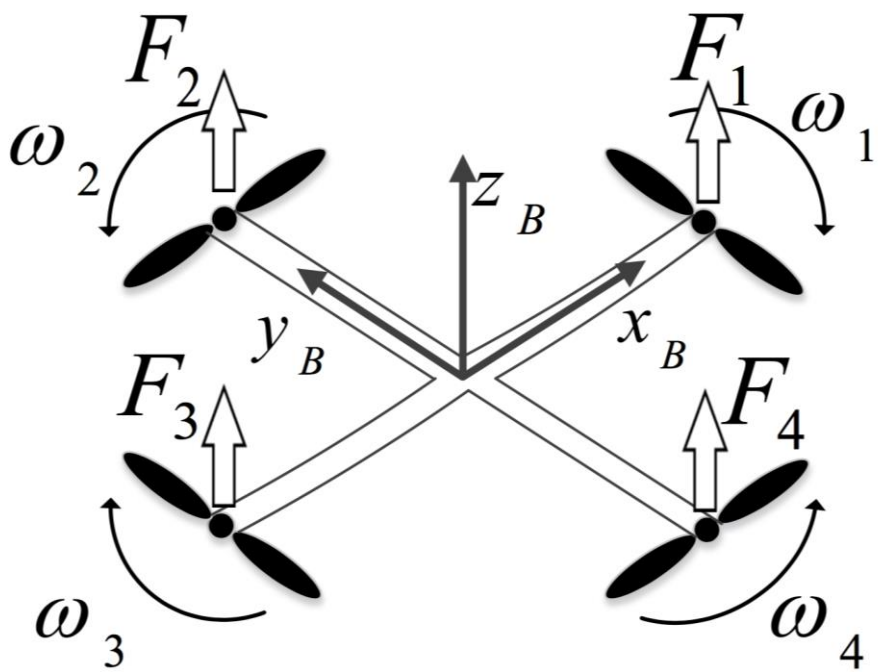
The drone movements modulate the wireless signal that sent from the transmitter attached to it



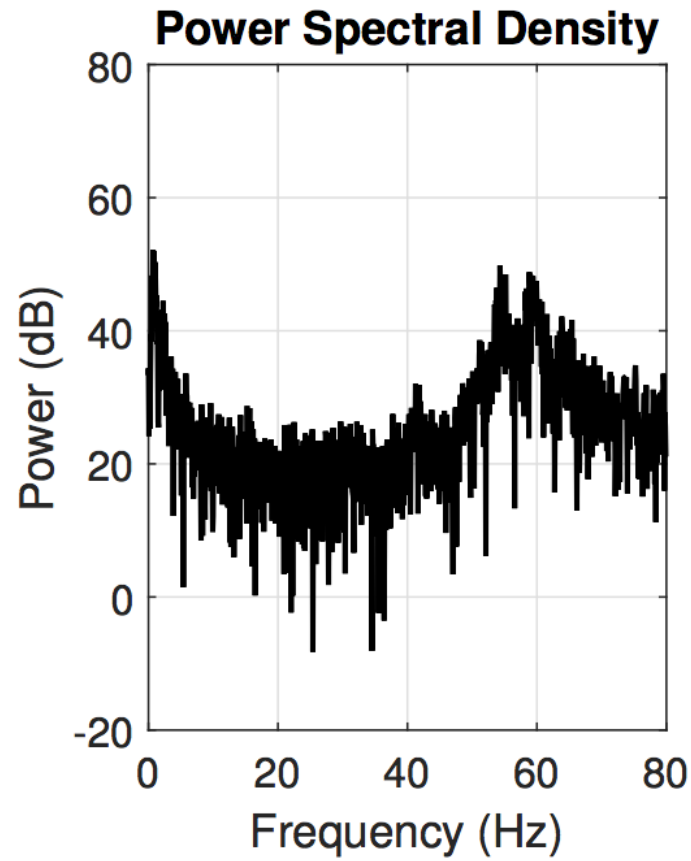
Validating the use of Wavelet Transform to detect body shifting



Body Vibration Observation

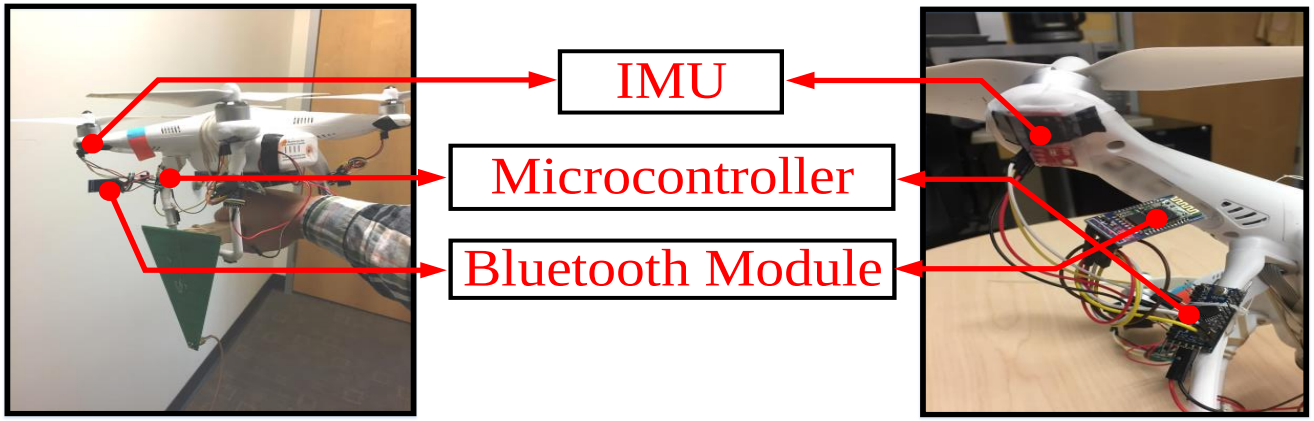


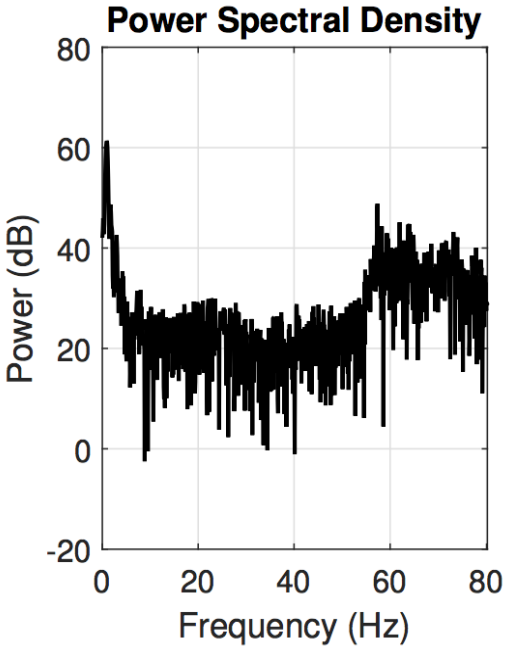
Body vibration signature



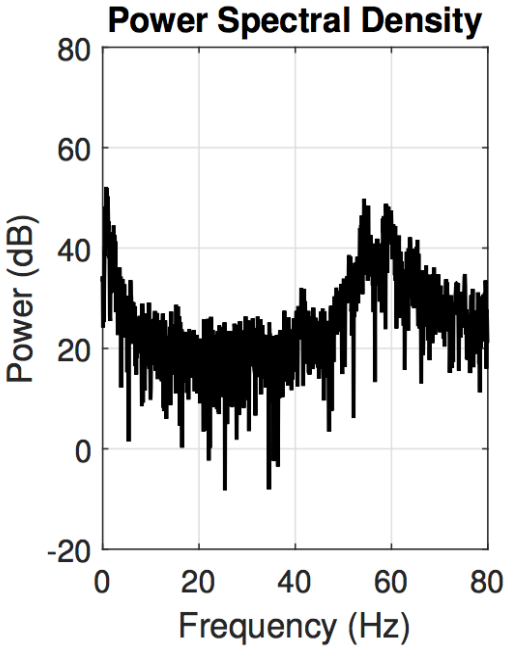
<u>Idea:</u> The body vibration of the drone can be detected by a Fast Fourier Transform analysis

Body Vibration Validation



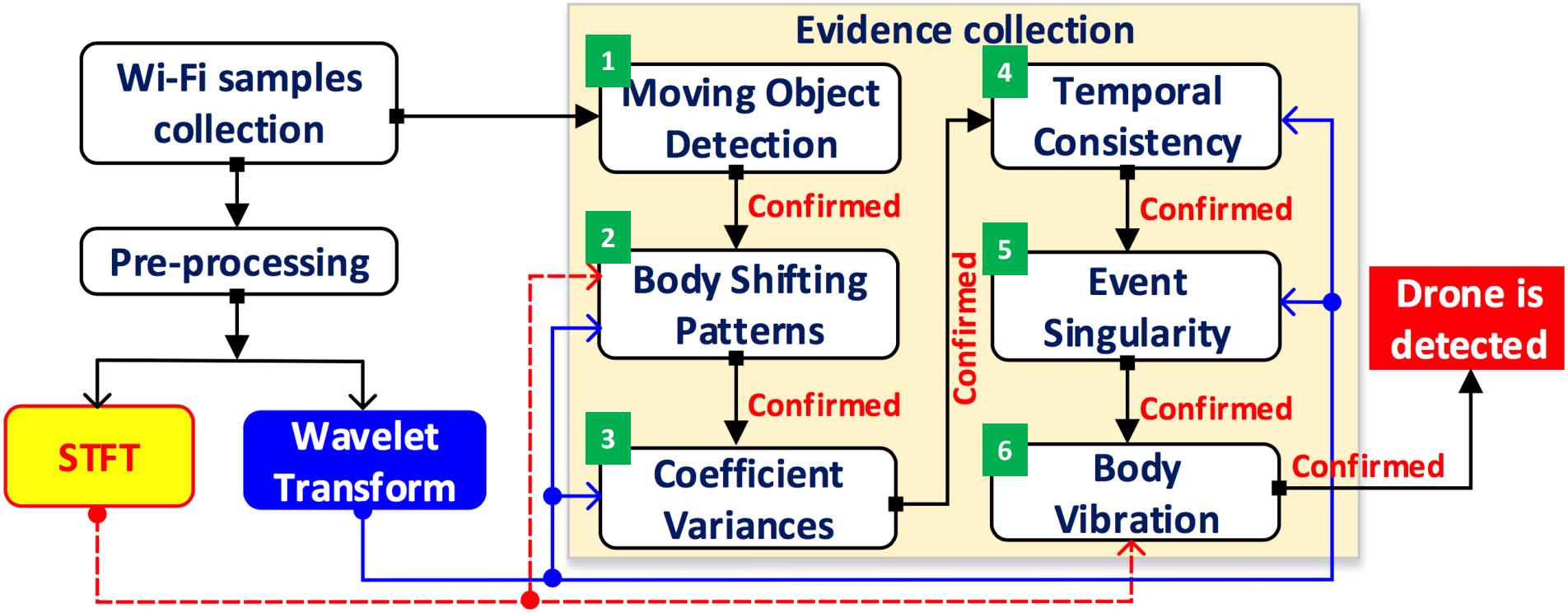


IMU data



Wireless data

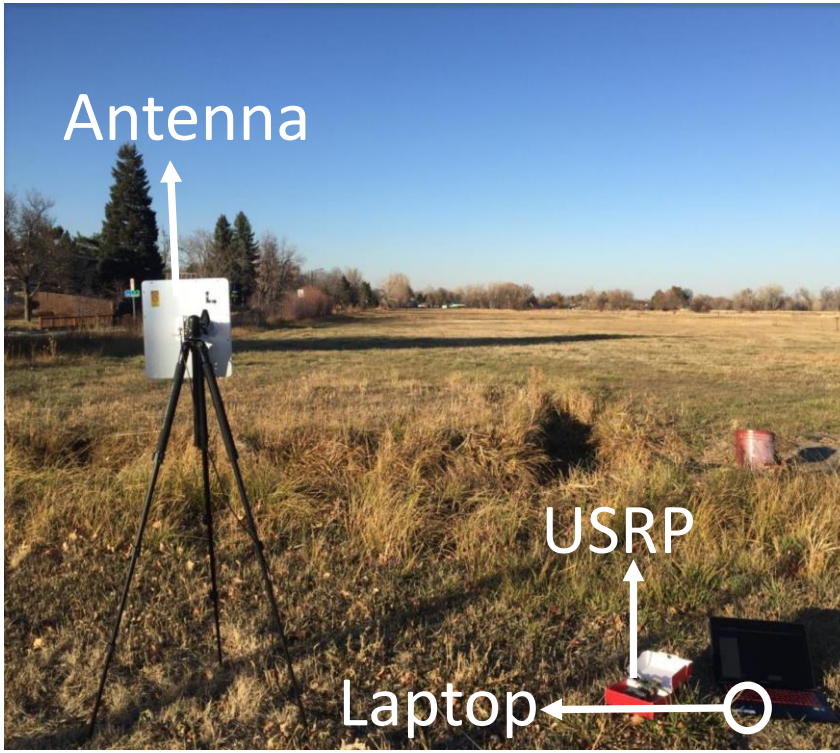
Matthan's Overview



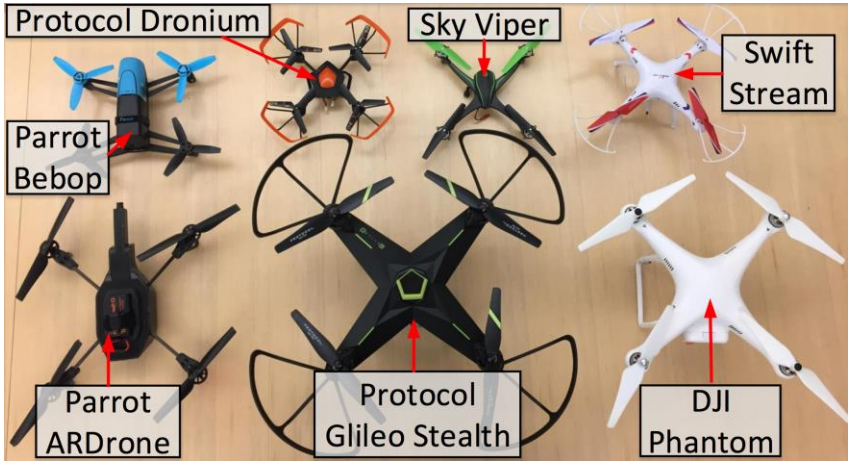
Evaluation

- Hardware
  - SDR USRP B200
  - 2.4GHz directional antenna
  - Carrier Sensing: Wi-Fi Analyzer app on Android

- Environment setup
  - Drones used: *Parrot Bebop, Protocol Dronium One Special Edition, Sky Viper, Swift Stream, Parrot AR Drone, Protocol Galileo Stealth, and DJI Phantom*
  - Environments: Urban, Campus, Sub-urban
  - Distance: 10m → 600m

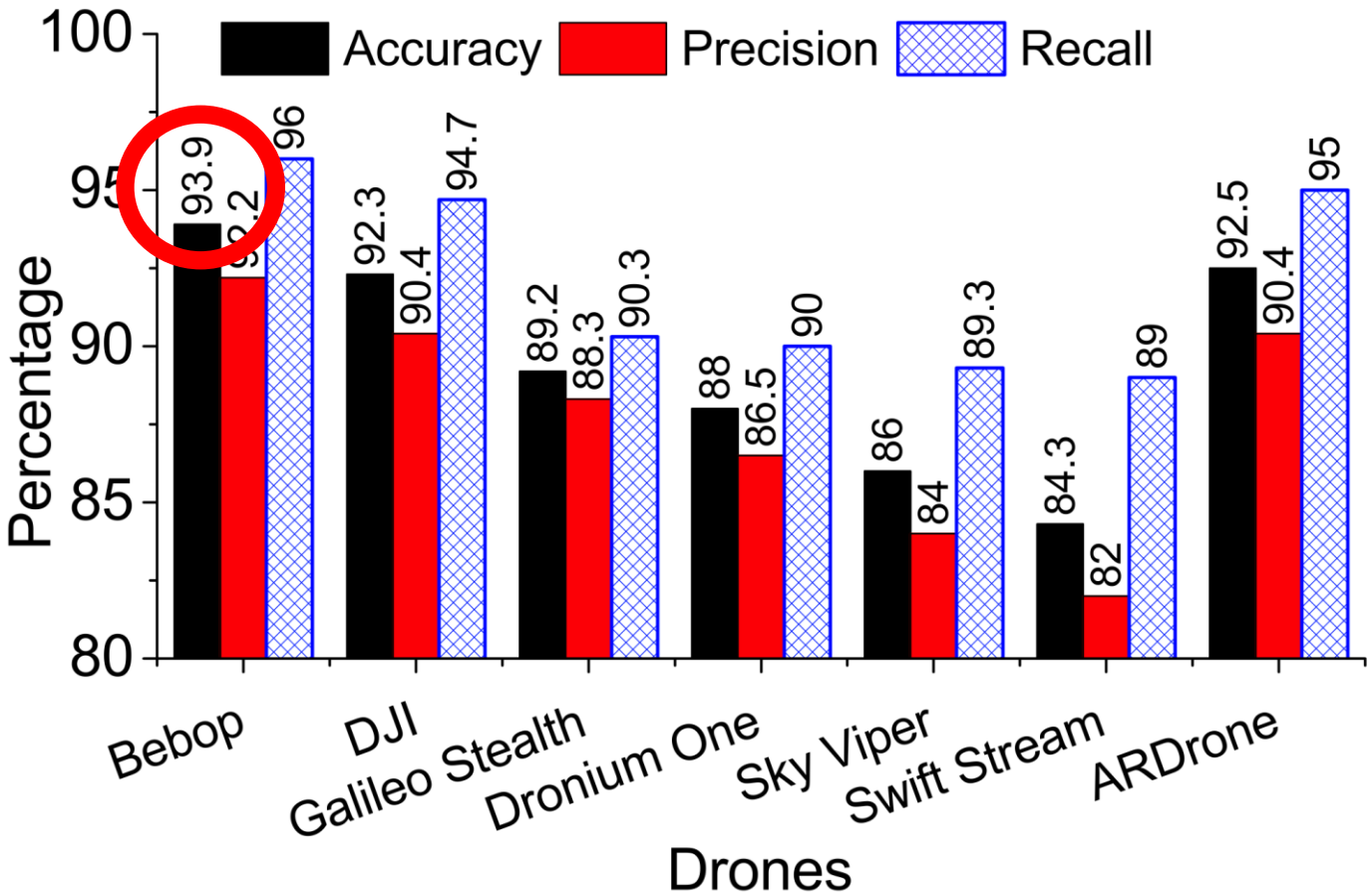


Setup



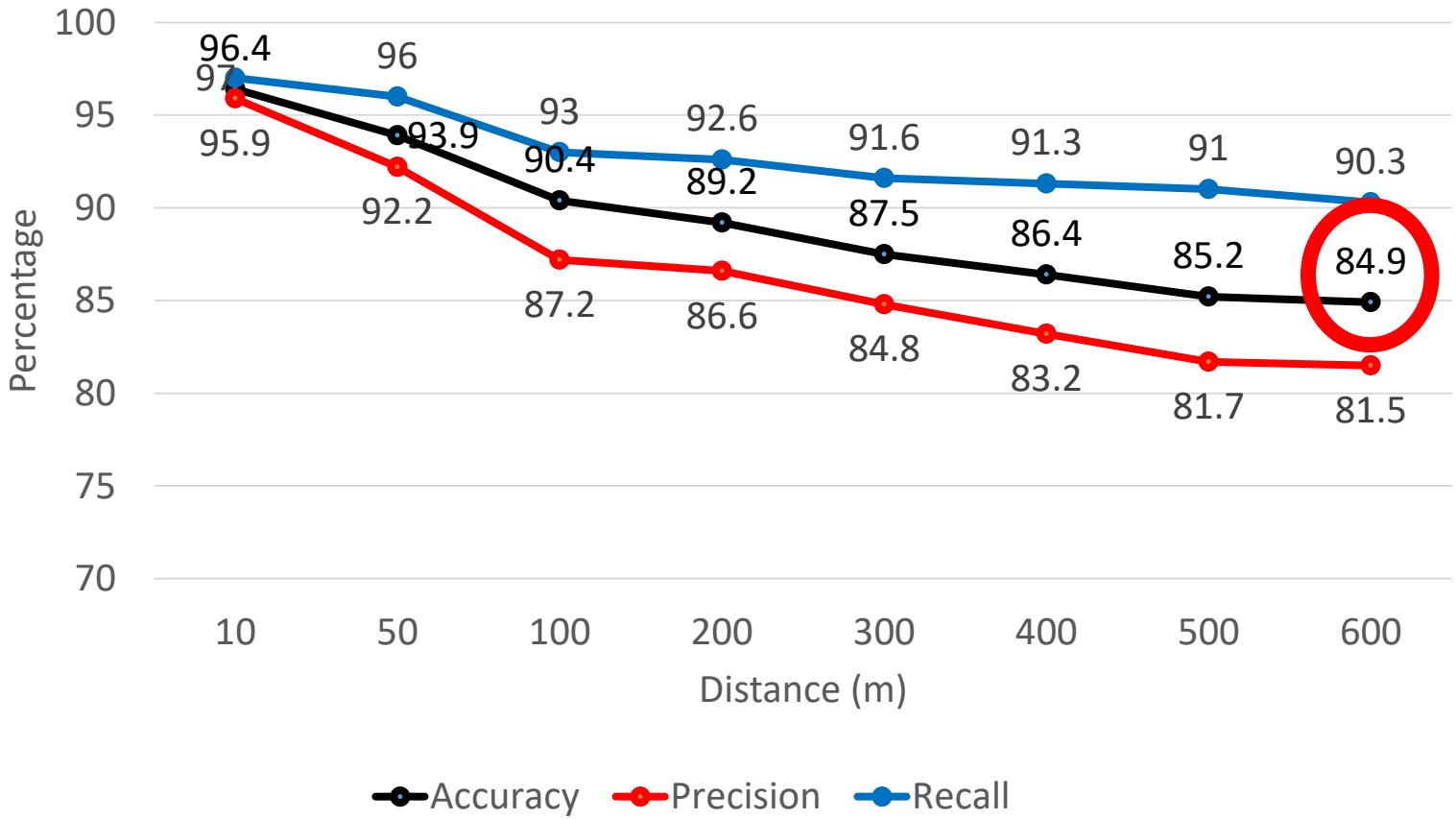
7 types of used Drones

Detecting Different Drones



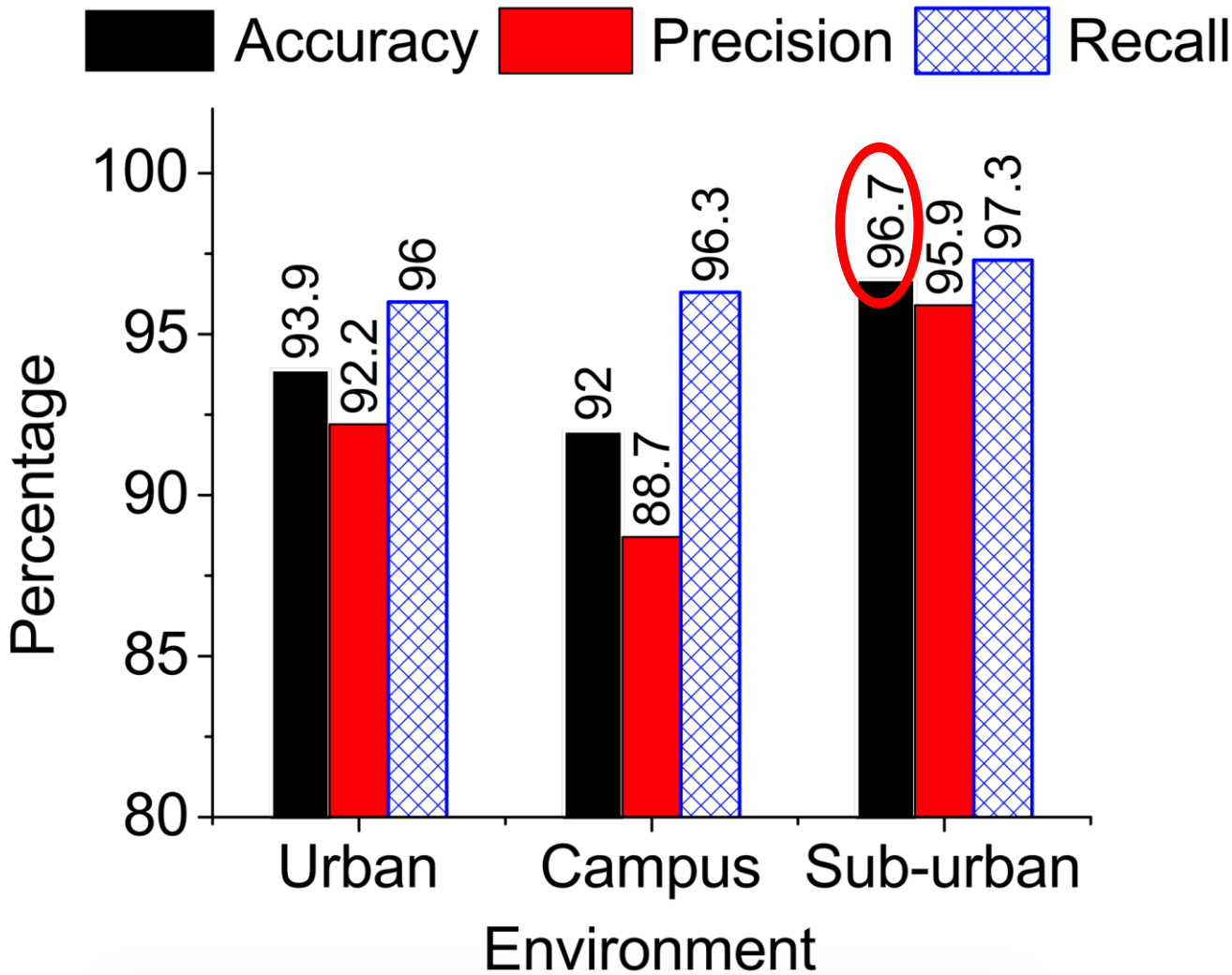
Distance = 50m

Detect Drones at Different Distances



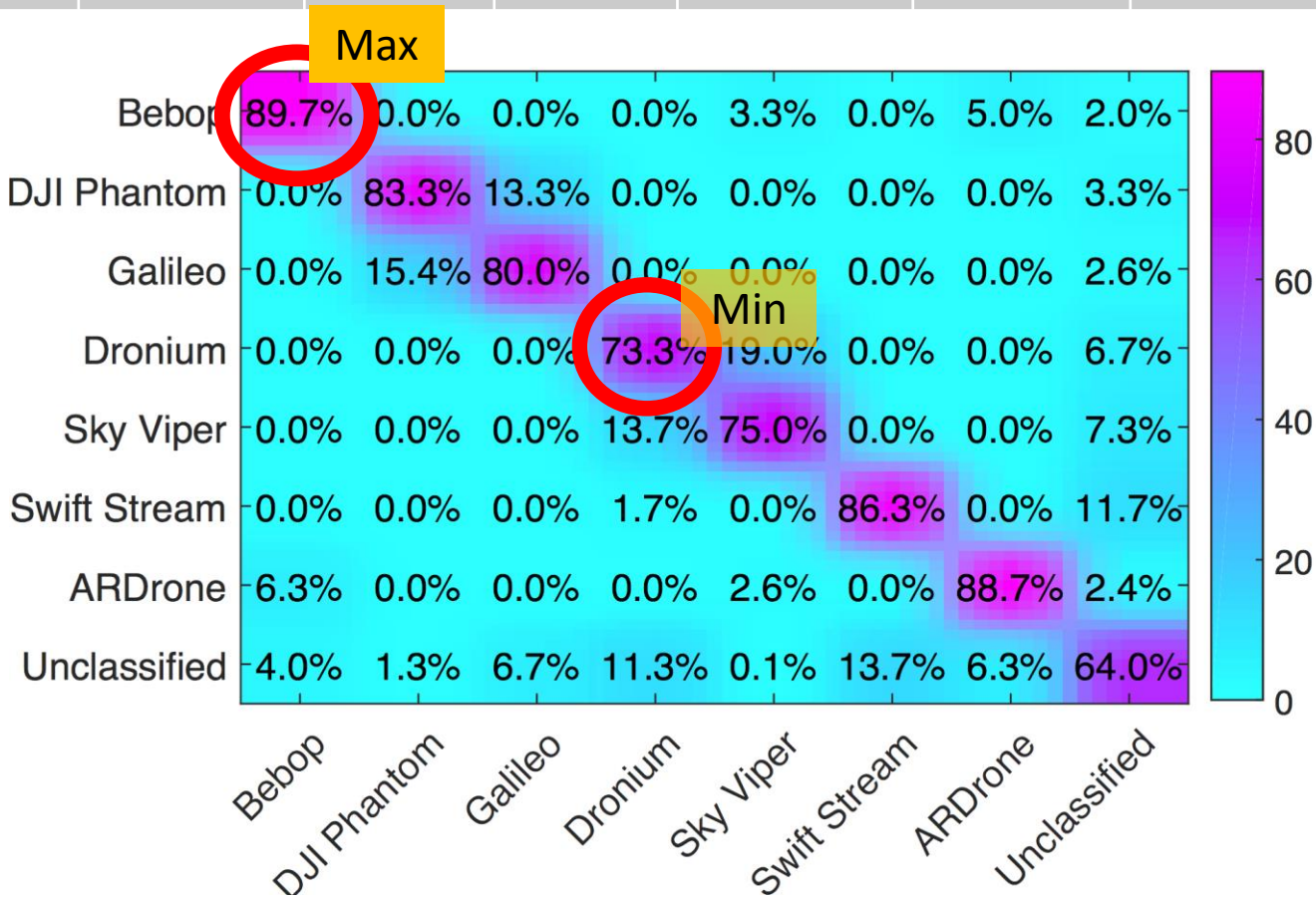
Distance from 10m to 600m

Detecting Drones at Different Environments



Drone Differentiation

Drone	Bebop	DJI	Galieo	Dronium	Sky Viper	Swift Stream	AR Drone
Vibration Freq.	60 Hz	100 Hz	140Hz	35 Hz	50 Hz	20 Hz	70 Hz



Future Works

- Develop an automated channel sensing (similar to cognitive radio spectrum sensing)
- Integrate automated steering/ beamforming antenna
- Localize the position of the drone
- Detect multiple drones at the same time

Conclusions

- We introduce a system to detect the presence of the drones by identifying unique signatures:
  - drone's body shifting and
  - drone's body vibration

- The system obtained high performance
  - at different distances,
  - in different environments, and
  - with different types of drones.

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